

**IN THE UNITED STATES
PATENT AND TRADEMARK OFFICE**

PATENT

Serial No.: 10/615,042)
 Filed: July 8, 2003)
 For: COPPER-LOW-K DUAL)
 DAMASCENE INTERCONNECT)
 WITH IMPROVED RELIABILITY)
 Inventors: Valeriy Sukharev et al.)
 Examiner: Jesse A. Fenty)
 Art Unit: 2815)
 Atty. Ref.: 03-0509)

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**DECLARATION OF VALERIY SUKHAREV
IN SUPPORT OF OFFICE ACTION RESPONSE**

1. I am one of the inventors of the above-identified patent application.
2. I have a Ph.D. degree from KARPOV INSTITUTE OF PHYSICAL CHEMISTRY, MOSCOW, RUSSIA, and I have 10 years experience in the semiconductor industry.
3. The independent claims of the above-identified application have been amended to specifically claim a permanent interconnect liner layer of aluminum-0.5% copper alloy. The major target of the present invention is to create an additional metal liner between the diffusion barrier (Ta/TaN) and the copper inside the vias and trenches. This liner should be characterized by a good electrical conductivity and at the same time by a good enough resistivity to the electromigration. This liner should survive during the chip lifetime. The present application claims using aluminum-0.5% copper alloy as the material for this liner.
4. In contrast, United States Patent No. 6,204,179 (McTeer) uses a sacrificial Al liner as a wetting underlayer to assist a gap-fill by copper reflow. McTeer needs this Al to lower the Cu reflow temperature (to prevent diffusion barrier material from the chemical erosion). As mentioned in column 18, lines 15-18, "...the aluminum wetting layer is consumed thereby forming a Cu_{sub}nAl alloy layer wherein n is an integer from about 0.5 to about 4". The Examiner has determined that this means 0.5% copper alloy, however, one having ordinary skill in the art would interpret McTeer, and specifically column 18, lines 15-18 of McTeer, to mean that the alloy is from interval of atomic compositions: from 2Al - 1Cu to 1Al - 4Cu, which means an alloy with Cu concentration from 33% to 80%, but not 0.5%.

5. To one having ordinary skill in the art, it is clear why McTeer needs such alloys. The melting point will be reduced almost twice when 40-50% of Al will be added to Cu (compared with the Cu melting point). In the present invention, this Cu concentration is not acceptable because it will dramatically increase a resistivity of the Al liner and will destroy the purpose of its employment.
6. United States Patent No. 6,150,252 (Hsu et al.) does not disclose or suggest a copper fill. In addition to specifically claiming a permanent interconnect liner layer of aluminum-0.5% copper alloy, the independent claims of the present invention specifically claim a copper fill. In contrast, Hsu et al. discloses filling with aluminum (see col. 9, lines 1-10).
7. An additional very important point that should be taken into account when comparing the present invention to McTeer and Hsu et al. is the complete difference in copper technology that is employed in the present invention. The present invention uses a standard dual damascene copper process, where copper is deposited by the electroplating (current standard). Everything that the present invention proposes is the introduction of an additional process step, which is a PVD-based deposition of Al-0.5% Cu liner on the top of the deposited diffusion barrier (TaN), in the standard process flow. McTeer has used the PVD technique for copper deposition, and this is a reason why McTeer needs to introduce a copper reflow step and to deposit a sacrificial Al liner.
8. Hsu et al. uses a high pressure processing for cavity filling. It is a two-step process: deposition of a thin liner, followed by deposition of a thicker layer to close the mouth of the cavity and high pressure processing to force the fill layer further into the cavity to complete cavity filling. (column 2, lines 55-58). Hsu et al. needs the first liner for wetting purposes only.

As a person signing below:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE

Inventor's Full Name (Printed) Valeriy Sukharev

Inventor's Signature V. Sukharev

Date 04/28/05

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